

15. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said solid state laser element is a crystal doped with a highly reactive rare earth metal.

16. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said solid state laser element is a neodymium doped crystal.

17. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said solid state laser element is a YLF crystal.

18. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said wavelength conversion element is a MgO doped LiNbO₃ crystal.

19. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said semiconductor resonator length is selected to cause a wavelength of said excitation light to remain within an absorption band of said solid state laser element.

20. (New) A semiconductor laser excited solid state laser apparatus as claimed in claim 1 wherein a wavelength of said excitation light is independent of a driving current of said semiconductor laser unit.

REMARKS

Claims 1-6 are pending in this application and stand rejected. Claim 1 is independent. By this amendment, Applicants amend claims 1 and 4 and add claims 7-20. Claims 1 and 4 are independent.

Status of Claims 1-6

Claims 1-6 were rejected under 35 USC 103(a) as being unpatentable over King et al. (U.S. Patent No. 5,642,375). Applicants respectfully traverse this rejection and submit the following arguments in support thereof.

Claim 1

The Examiner has stated that Figure 8 of King illustrates a laser system having two resonant cavities (108) and (110), where cavity (108) has a gain medium and cavity (110) has a nonlinear crystal and that the laser system of figure 8 is excited to produce high intensity light. The Examiner acknowledged that King does not disclose a laser cavity (108) that has a length of at least 0.8 mm, but points out that at column 10 lines 51-60 King discloses a relationship between the two cavities expressed as a ratio. According to the Examiner, a person having ordinary skill in the art has the capability of understanding the scientific and engineering principles applicable to the claimed invention and is therefore, capable of discovering optimum or working ranges using the relationship of the cavities established by King to obtain a laser system which will provide light of high intensity.

The embodiment of the invention of claim 1 includes a solid-state laser apparatus that is excited by light from a semiconductor laser. The solid-state laser apparatus includes a semiconductor laser unit with a laser unit resonator and includes a solid-state laser element that emits laser light in response to excitation by the semiconductor laser light. The length of the laser unit resonator is at least 0.8 mm and is dependent upon a characteristic of the solid state laser element.

King discloses a laser system in which a gain medium, first ("laser") and second ("common") mirrors that define a laser cavity in which the gain medium is located, and a third ("external") mirror, spaced from the common mirror to define an external cavity, are selected to optical lock the gain medium to the resonant frequency of the external cavity (col. 6, lines 2-8). King also discloses that above the laser threshold, the bandwidth of a two-mirror cavity depends on the reflectivities of the two-mirrors, with higher the reflectivities producing smaller bandwidths (col. 7, lines 25-27) and that light in the laser cavity will have the same optical properties as the light in the external cavity when the narrow bandwidth component dominates as the gain of the gain medium approaches the laser threshold (col. 7, lines 34-38). The reflectivities for the common and external mirrors are much higher than that of the laser mirror. Therefore, the bandwidth of the external cavity will be much narrower than that of the laser cavity (col. 7, lines 28-29).

As taught by King, light emitted from the gain medium is transmitted to the external resonant cavity, and resonates inside to reach high intensity. A portion of the high intensity, external cavity light is transmitted back to the laser cavity through the common mirror. Since the narrower bandwidth external cavity light will reach the lasing threshold at the lower optical gain, the gain medium will be dominated by the light that feeds back from the external cavity (col. 7, lines 52-56), and the light in the two cavities will have the same optical properties (will be "optically locked"). Thus, optical locking of the resonant frequency of the external cavity to that of the laser cavity in King (col. 6, lines 9-20) requires a fixed relationship between the lengths of the two resonators, as the Examiner has pointed out. The present invention requires no such relationship.

As known to those skilled in the art, during operation, the build up of heat in a semiconductor laser resonator causes the wavelength of the excitation light to deviate from the absorption band of the gain medium. In currently available systems, the excitation laser light wavelength is often restored to the gain medium absorption band by increasing the current that is supplied to drive the source of the excitation light (i.e. the unit that houses the semiconductor laser). In contrast, the present invention can maintain the excitation light wavelength in the absorption band of the solid state laser element without requiring an increase in driving current. The increased length of the first (semiconductor

laser unit) resonator causes more physical contact between the resonator and the heat sink, and enables the semiconductor laser unit to efficiently dissipate the heat that builds as the unit operates. This eliminates the need for continuously increasing driving current, and allows the excitation light to be selected based upon the characteristics of the associated solid state element.

Independent claim 1 has been amended to emphasize that the length of the resonator is dependent upon a characteristic of the solid state element. This feature was disclosed in the originally filed application on page 14 beginning at line 10. No new matter has been added.

As the foregoing illustrates, independent claim 1 is patentable over King, Applicants respectfully request withdrawal of the rejection under 35 USC §103(a) and allowance thereof of claim 1.

Claims 2 and 3

The embodiments of the invention disclosed in claims 2 and 3 provide specified lengths for the first resonator. The embodiment of claim 2 includes a first resonator length that is at least 1 mm, while claim 3 includes a length that is at least 1.5 mm. Claims 2 and 3 are dependent upon claim 1, and allowable because claim 1 is allowable. Applicants respectfully request withdrawal of the rejection under 35 USC §103(a) and allowance of claims 2 and 3.

Claim 4

Claim 4 has been written in independent form to include its originally claimed features and also to emphasize that the length of the first resonator is not dependent upon the length of the second resonator, as explained in the originally filed application at page 4, beginning at line 19. No new matter has been added.

Applicants submit that claim 4 is patentable over King for at least the reasons set forth herein. Applicants respectfully request withdrawal of the rejection under 35 USC §103(a) and allowance of claim 4.

Claims 5 and 6

Like claims 2 and 3, the embodiments of the invention of claims 5 and 6 disclose resonator lengths of at least 1 mm and 1.5 mm respectively. Claims 5 and 6 are dependent upon claim 4, and allowable because claim 4 is allowable. Applicant respectfully requests withdrawal of the rejection under 35 USC §103(a) and allowance of claim 5.

Claims 7-20

Newly added claims 7 - 13 are dependent upon claim 1 and are allowable because claim 1 is allowable. Newly added claims 14-20 are dependent upon claim 4 and are allowable because claim 4 is allowable.

The embodiments of the invention claimed in claims 8-10 and 15-17 relate to characteristics of a solid state laser element that may be used with the invention. These features have been disclosed in the originally filed specification, for example, at page 9, beginning at line 25. The embodiment claimed in claim 18 relates to characteristics of a wavelength conversion element, as described on page 9 at line 16, while claim 11 relates to characteristics of a wavelength conversion element that may be used, as described on page 10 at line 22. No new matter has been added.

Claims 7, 12 and 13 relate to embodiments of the invention in which resonator length is dependent upon the absorption band of the solid state laser element as set forth in the originally filed specification on page 4, beginning at line 6. Claims 14, 19 and 20 are directed to features relating to the independence of the excitation light wavelength from driving current as described on page 6, beginning at line 10. No new matter has been added.

Applicant respectfully requests allowance of new claims 7-20.

Attached hereto is a marked up version of the changes made to the claims by the current amendment. The attached page is captioned:

"Version with markings to show changes made."

CONCLUSION

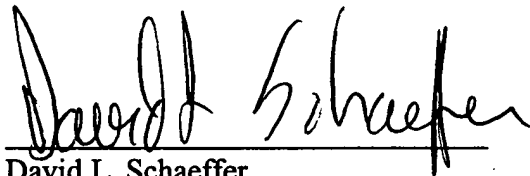
Applicants submit that claims 1-20 are allowable for at least the reasons set forth above. In view of the foregoing revisions and remarks, Applicants respectfully

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submit that all outstanding rejections and objections have been addressed and are now either overcome or moot, and that all claims pending in this application are patentable over the prior art. Reconsideration and withdrawal of the rejections and objections is respectfully requested.

The Commissioner is hereby authorized to charge the amount of the fee required under 37 CFR 1.136 and any other fee now or hereafter owed to the undersigned attorney's Deposit Account No. 19-4709.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "David L. Schaeffer", written over a horizontal line.

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Version With Markings to Show Changes Made

In the Claims:

Please amend claims 1 and 4 as follows:

1. (Amended) A semi conductor-laser excited solid state laser apparatus comprising:
- a semiconductor laser unit including a first resonator; and
 - a solid-state laser element which emits laser light in response to ~~is excited~~ excitation light emitted from the said semiconductor laser unit, ~~and emits laser light~~;
- wherein said first resonator has a length of at least 0.8 mm, with said first resonator length being dependent upon a characteristic of said solid state laser element.
4. (Amended) A semi conductor-laser excited solid state laser apparatus ~~according to claim 1~~ further, comprising:
- a semiconductor laser unit including a first resonator having a length of at least 0.8 mm;
 - a solid-state laser element which emits laser light in response to excitation light from said semiconductor laser unit;
 - a second resonator with a second resonator length, which is formed by ~~wherein~~ said second resonator includes said solid state laser element and a mirror arranged outside of said solid state laser element, with said first resonator length being independent of said second resonator length; and
 - a wavelength conversion element arranged in said second resonator, which generates a second harmonic wave.

Please add the following new claims 7 – 20:

7. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 1 wherein said first resonator length is dependent upon absorption band of said solid-state laser element.

8. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 1 wherein said solid state laser element is a crystal doped with a highly reactive rare earth metal.

9. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 1 wherein said solid state laser element is a neodymium doped crystal.

10. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 1 wherein said solid state laser element is a YLF crystal.

11. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 1 wherein said solid state laser element is a component of a Fabry-Perot solid state laser resonator.

12. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 1 wherein said first resonator length is selected to cause a wavelength of said excitation light to remain within an absorption band of said solid state laser element.

13. (New) A semiconductor laser excited solid state laser apparatus as claimed in claim 1 wherein a wavelength of said excitation light is independent of a driving current of said semiconductor laser unit.

14. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said first resonator length is selected based upon an absorption band of said solid-state laser element.

15. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said solid state laser element is a crystal doped with a highly reactive rare earth metal.

16. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said solid state laser element is a neodymium doped crystal.

17. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said solid state laser element is a YLF crystal.

18. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said wavelength conversion element is a MgO doped LiNbO₃ crystal.

19. (New) A semi conductor-laser excited solid state laser apparatus as claimed in claim 4 wherein said semiconductor resonator length is selected to maintain a wavelength of light exiting said second resonator in an absorption band of said solid state laser element.

20. (New) A semiconductor laser excited solid state laser apparatus as claimed in claim 1 wherein a wavelength of light emitted from said semiconductor laser unit is independent of a driving current of said semiconductor laser unit.